The Togai InfraLogic Inverted Pendulum Demonstration

OVERVIEW

This demonstration consists of a simulated inverted pendulum that is controlled by a fuzzy logic knowledge base. ' The fuzzy logic knowledge base was developed with the Togai InfraLogic Fuzzy-C Development System. Source code is available in the file "PENDSRC.ZIP".

SYSTEM REQUIREMENTS

To run the pendulum demonstration, you need:

- An IBM-PC or compatible.
- An EGA adapter and monitor.
- 256K of memory.
- DOS 3.3 or higher.

INSTALLATION AND EXECUTION

To install the pendulum demonstration onto your hard disk, do the following:

- Make a directory called pend (type "md pend").
- Go into that directory (type "cd pend").
- Copy the archive into the directory.
- Extract the files from the archive (type "pkunzip pendemo.zip").
- Run the demonstration (type "pendemo").

DESCRIPTION

This is a demonstration of fuzzy logic control using a stationary inverted pendulum with a variable weight and variable motor strength. The demonstration is designed for "hands on" evaluation as to how fuzzy logic works. To run the demonstration, type "pendemo". The demonstration will immediately begin with the default settings. Before proceeding, hit the "?" key and page through the help menus. This should give you a good overview of how the demonstration works.

The demonstration scree is divided into five display windows as follows:

1. The center window shows the pendulum itself. These are the main features of this window:

   - The red bob at the top of the pendulum is a user alterable mass. You can increase or decrease the mass of the bob with the F6 and shift-F6 keys respectively.

   - The green stick separates the bob from the motor. You can cause the length of the stick to vary (which considerably alters the physics of the system) by pressing the F7 key.

   - The blue ball at the bottom of the pendulum is a motor which, when given current, drives the stick one way or the other. You can increase or decrease the strength of the motor with the F5 and shift-F5 keys.

The other items in the window reflect the status of these main features.

2. The upper right window shows the fuzzy logic production rules that control the pendulum in a matrix style. Each element in the matrix corresponds to a rule. For example the center element in the matrix reads:

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IF Theta is Z and dTheta is Z THEN
    Current = Z
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   If a rule is firing in the knowledge base, the matrix element corresponding to the rule is highlighted in gray.

3. The lower right window consists of two main sections: the rule list and the currently selected rule display.

   You can scroll through the rule list with the up and down arrows of your PC. Scrolling through the list dynamically sets the highlighted rule in the rule list to be the "current rule". The current rule is then graphically displayed in the current rule display section.

   If you press the F1 key, the current rule is disabled in the knowledge base and the system behaves as though the rule does not exist. You can re-enable the rule by pressing F1 again.

4. The lower left window displays the system from a black-box perspective. The crisp values for Theta and dTheta are shown at the top of the window (the inputs) while the crisp value for the motor current is displayed at the bottom of the window (the output).

   The middle portion of the window shows the combined fuzzy output for all the rules that fired in the knowledge base over one cycle. The final crisp value (for that cycle) for motor control is determined by what is called the centroid defuzzification technique. This process computes the moment and area for the fuzzy output polygon (shown in red in the center of this window) and then divides the moment by the area to get a crisp value.

5. The upper left window is a trace buffer showing the motor current as it varies over time.

Just as in standard production rules, fuzzy logic production rules have a premise, or IF portion, and a conclusion, or THEN portion. However, there are two major differences between fuzzy production rules and standard production rules: first, each variable of the premise and conclusion has a set associating it to its "level of belief". Secondly, all rules within the fuzzy logic knowledge base which fired are used in calculating the resulting output. The resultant combination of all of the rules fired is shown in the display in the lower left window.

The premise or IF portion of the rule is evaluated by translating an input signal to a level of belief by imposing the input upon the membership function (which represents the association between the linguistic variable in the fuzzy production rule such as "negative small (NS)" or "positive medium (PM)"). The minimum value of all of the levels of belief of the premise portion of the rule is used as the output to conclusion. This value is known as the alpha. If alpha is not zero the rule has been fired.

The conclusion or THEN portion of a rule is evaluated by imposing the alpha onto the conclusion membership function such that the conclusion membership graph is "clipped" by the alpha value. For all of the rules which were fired the graphs are combined with a logical OR resulting in the polygon in the lower left window. This result is then converted into a "crisp" output by taking the centroid of the graph.

One of the most valuable attributes of fuzzy logic is its elasticity. This can be demonstrated by selecting and deselecting the rules to see their effect. This is done by placing the cursor over a rule in the lower right window and hitting the F1 key. There are 25 possible two input and one output fuzzy production rules for this system (11 are used in the demonstration) with a single conclusion shown as each position in the matrix. However, the actual number of rules required to control an inverted pendulum is about seven. Thus, some of the production rules can be eliminated.

PERTINENT FILES

- pendemo.doc This file.

- pendemo.exe Run this program to see the demonstration.

CONTACT

If you have any comments, suggestions, or questions, please contact Togai InfraLogic, Inc. at:

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